

Coastal Zone
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Center

Socio-Economic and Environmental Inventory of the North Atlantic Region Sandy Hook to Bay of Fundy

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Executive Summary

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**A Socio-Economic and Environmental
Inventory
of the
North Atlantic Region**

including the Outer Continental Shelf and adjacent
waters from Sandy Hook, New Jersey, to Bay of Fundy

EXECUTIVE SUMMARY

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Submitted to Bureau of Land Management, Marine Minerals Division
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The Research Institute of the Gulf of Maine
Box 2320
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ABSTRACT

A ten month study by The Research Institute of the Gulf of Maine (TRIGOM) was conducted to gather and inventory the existing environmental socio-economic data of the coastal zone and adjacent outer continental shelf (OCS) from Sandy Hook, New Jersey, to Bay of Fundy. These data were based on the requirements for impact assessments prior to leasing offshore areas for oil, gas, and mineral exploration and production. The marine boundaries were Hudson Canyon, the 200 meter contour, and the Canadian international line; shoreward, the limit of salt intrusion was the boundary while some 38 counties were inventoried for socio-economic data. Over 300 persons were contacted or interviewed, 3800 documents reviewed for data by about 40 scientists and consultants. The following list shows the major topics inventoried and presented in the report:

Environmental

- Geological Oceanography and Hydrology
- Physical Oceanography
- Chemical Oceanography
- Meteorological Oceanography

Systems Ecology by Habitat

- Phytoplankton, Zooplankton, Benthic Invertebrates, Macrophytes, Fishes, Birds, Mammals

Unique and Endangered Environments

- Rare, Endangered, and Threatened Species

Environmental Quality

Socio-Economic

- Demography
- Petroleum
- Recreation
- Transportation
- Fisheries
- Land and Water Use

Biological data of plants and animals and their environmental relationships have been organized according to a functional habitat-system approach rather than by taxonomic categories alone. Ten habitats are presented with about 150 representative key species. Life history profiles for key species are included along with checklists of reported species in each habitat. A series of maps of the areal extent of the habitats was prepared. Water and air quality print-outs for all coastal towns and counties are included. The report in 3 volumes is about 4900 pages in length with over 700 illustrations and 300 tables.

PREFACE TO FINAL REPORT

The material and data contained in this report have been furnished to the Bureau of Land Management under the terms of Contract 08550-CT3-8. TRIGOM, as contractor, takes full responsibility for any errors or misstatements which may still exist. This inventory was put together from a large number of sources in a ten month period. In an effort of this size, operating on a very tight time schedule, there are likely to be a number of typographical and inadvertent errors. We ask the forbearance of our colleagues and our sponsor in accepting this edition as a working document which we hope will be used, corrected, and updated in the future. Any suggestions for changes and additions will be welcomed by TRIGOM.

At the time of submission of this report Appendix D, the bibliography, is still in preparation and will be included early in 1975 in a separate Book as the last part of Volume Three. This part will also include a detailed index to all chapters.

The Staff and Editors at TRIGOM thank the many authors and contributors to this study.

Edward H. Shenton, Program Manager
Portland, Maine
November 1974

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1.0 INTRODUCTION

This report presents the final results of a ten-month study entitled a SOCIO-ECONOMIC AND ENVIRONMENTAL STUDY OF THE NORTH ATLANTIC COAST AND CONTINENTAL SHELF FROM BAY OF FUNDY TO SANDY HOOK, NEW JERSEY. The Study was conducted jointly by the staff of TRIGOM (The Research Institute of the Gulf of Maine) and PARC (Public Affairs Research Center, Bowdoin College) for the United States Department of Interior, Bureau of Land Management (BLM), Marine Minerals Division, under contract 08550-CT3-8 during the period June 29, 1973 to July 29, 1974.

1.1 BACKGROUND

As a nation looking for possible solutions to our need for additional energy sources, attention has been focused on the potential of the Outer Continental Shelves (OCS) off New England and the mid-Atlantic regions. The OCS of the United States has proven to be a prolific supplier of oil and gas in the Gulf of Mexico and offshore California. Development of the OCS must be preceded by analyses of potential impacts upon the related environments, according to the National Environmental Policy Act (NEPA) of 1969. To perform such analyses, the existing environmental data together with the various existing economic factors of the areas must be described.

The primary purpose of this study has been to gather available data describing the existing environment of the coastal zone and adjacent continental shelf of the North Atlantic area (both natural and socio-economic) and present these data in comprehensive descriptions.

1.2 SCOPE OF WORK

1.2.1 AUTHORIZATION

The scope of the study was initially defined in a Request for Proposal (RFP BLM 73-2) April 2, 1973, and was amended by the proposal of TRIGOM dated May 30, 1973.

1.2.2 GEOGRAPHICAL AREA COVERED

The regional coverage from Sandy Hook, New Jersey, to Bay of Fundy was established with boundaries shown on Figure 1-1. The marine boundaries were loosely defined as the Hudson Canyon on the South, the 200 meter contour along the continental shelf, and an undetermined international boundary between the United States and Canada. The shoreward extent was generally agreed to be the coastal zone or extent of salt water intrusion for marine environmental data, and the coastal counties for socio-economic data. These counties are listed in Table 1-1.

In the process of conducting the study, these arbitrary boundaries were in some cases varied.

1.2.3 TOPICAL COVERAGE

A detailed outline of the topics to be reviewed and mentioned as agreed in the contract is presented in Appendix F. Table 1-2 contains an abbreviated list of subject areas reviewed in the report.

1.3 OBJECTIVES

1.3.1 PRIMARY OBJECTIVES

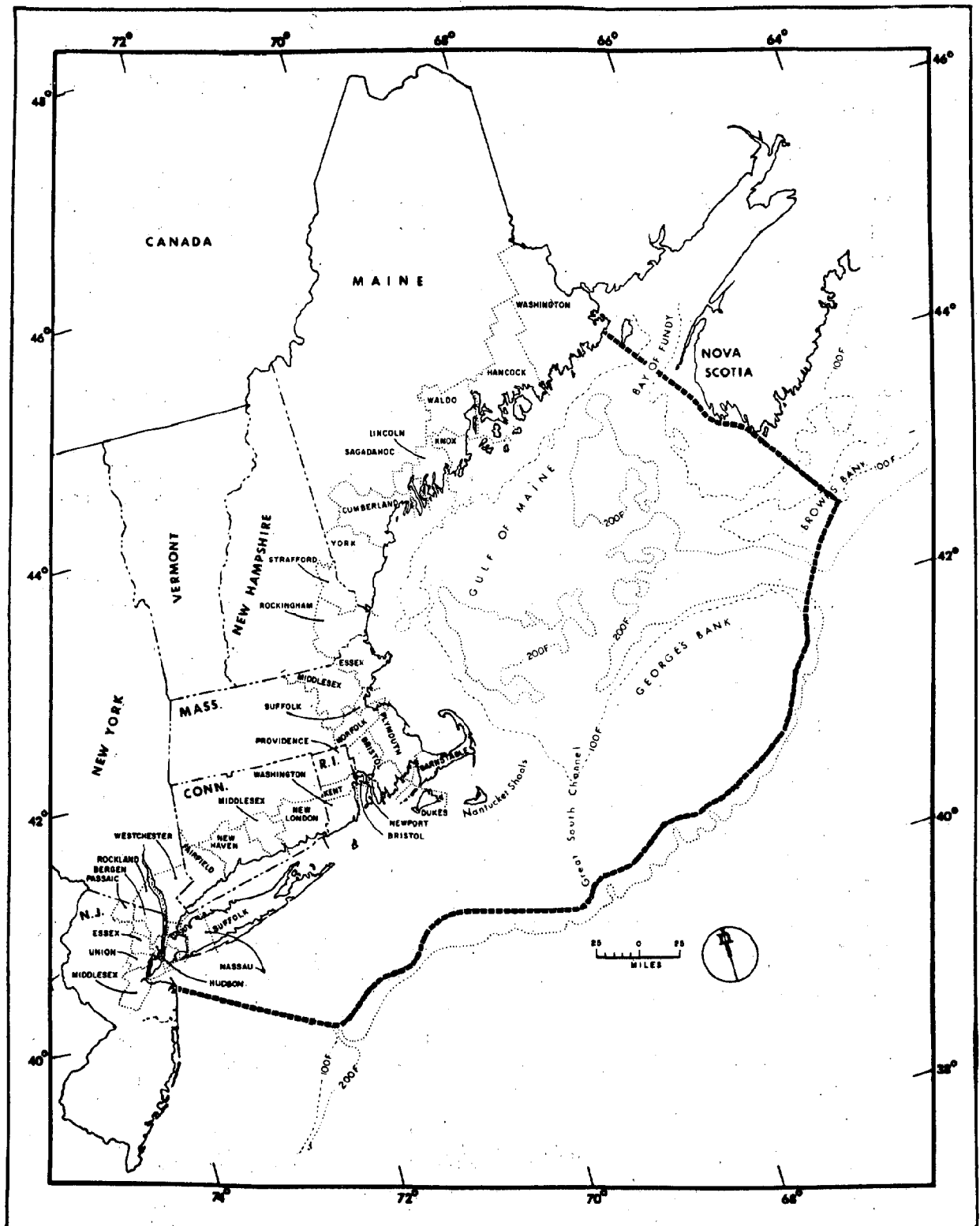
The primary objectives of this socio-economic and environmental inventory of the North Atlantic region were:

- To develop a comprehensive inventory of marine environmental data for the coastal zone and adjacent waters of the outer continental shelf
- To conduct a study of the socio-economic factors operating in the region from Bay of Fundy (Eastport, Maine) to Sandy Hook, New Jersey
- To combine these previous steps into a comprehensive compilation for use in preparing impact assessments of the development of offshore energy resources.
- To define the gaps and deficiencies that exist in the present information baseline as preliminary to conducting new research and field surveys.

1.3.2 SECONDARY OBJECTIVES

A secondary set of objectives which altered the scope of work and made major demands on the project was added just prior to contract negotiation. This addition was requested to meet the requirements of the Council on Environmental Quality (CEQ), which included:

- Provision of general biological habitat descriptions for the two biographical regions including key species for each one
- Mapping the areal extent of these habitats
- Provision of a specific list of life history data for all key species



A SOCIO-ECONOMIC AND ENVIRONMENTAL INVENTORY OF THE NORTH ATLANTIC REGION		
TRIGON PARC	FIGURE	The Study Region
	1-1	

Table 1-1 BLM North Atlantic Inventory: List of coastal counties

Maine:

Washington
Hancock
Waldo
Knox
Lincoln
Sagadahoc
Cumberland
York

New Hampshire:

Strafford
Rockingham

Massachusetts:

Essex
Middlesex
Suffolk
Norfolk
Plymouth
Barnstable
Nantucket
Dukes
Bristol

Rhode Island:

Newport
Bristol
Providence
Kent
Washington

Connecticut:

New London
Middlesex
New Haven
Fairfield

New York:

Suffolk
Nassau
Westchester
Rockland
New York City (5 counties)

New Jersey:

Bergen
Passaic
Hudson
Essex
Union
Middlesex

Table 1-2 General Topics Inventoried

Environmental Inventory

- Meteorological Oceanography
- Physical Oceanography
- Geological Oceanography
- Chemical Oceanography
- Biological Oceanography
- Systems Ecology
 - Plankton-based pelagic
 - Benthos
 - Mussel-Oyster Reefs
 - Worm Clam Flats
 - Salt Ponds
 - Salt Marshes
 - Sandy Shores
 - Rocky Shores
 - Shoreland Strand
 - Terrestrial
- Phytoplankton
- Zooplankton
- Benthic Invertebrates
- Macrophytes
- Fishes
- Birds
- Mammals
- Unique and Endangered Environments
- Rare, Endangered and Threatened Species
- Environmental Quality

Socio-Economic Inventory

- Demography
- General Economy
- Petroleum and Petrochemicals
- Recreation
- Transportation
- Fisheries
- Other Marine Activities
- Land and Water Use
 - Urban
 - Rural
 - Archaeological and Historic Sites
- Land Use Plans
- Land and Water Use Controls

1.4 METHODS AND APPROACH

This section will describe the methods and approaches used in the compilation of the environmental inventory. A similar discussion of the socio-economic inventory follows in Chapter 18. A set of tasks was initially developed, organized around four major areas as shown on Figure 1-2. It should be noted that, to a large extent, the tasks were conducted concurrently.

TASK 1: DATA COLLECTION (INITIAL)

- Organize the program approach - conduct a local workshop
- Review the literature and data source
- Conduct a pilot study of Maine
- Develop the overall study requirements

Approach

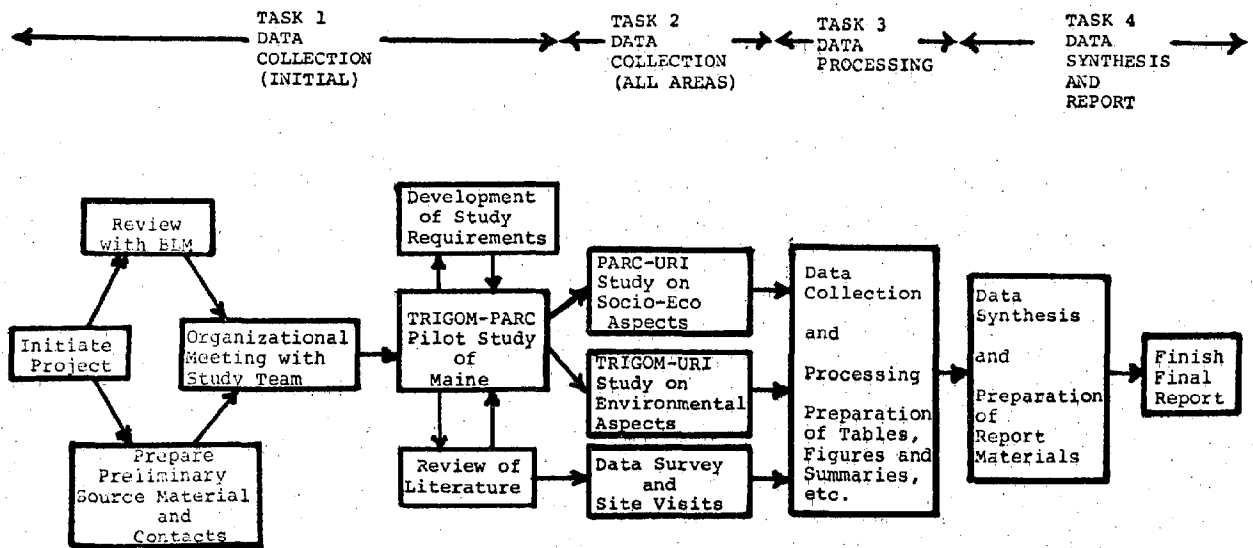
The intent of the task was to develop the proper techniques and requirements for the rest of the program by conducting a pilot study of the state of Maine where we could test a variety of approaches quickly and inexpensively and incorporate these into the larger survey of the entire region.

Method

The pilot study, however, was diverted by the pressing needs of the CEQ contractor, the Massachusetts Institute of Technology (MIT). An extremely short period of time was available in which to supply specific biological and areal descriptions. As a result, a separate set of interim tasks was established to provide MIT scientists with detailed biological habitat information. These data were presented in two sets of working papers (TRIGOM 1973a and 1973b). Results of this task largely influenced the subsequent organization and conduct of the remainder of the study as will be described in Regional Overview of Biology, Chapter 2.4.

TASK 2: DATA COLLECTION (ALL AREAS)

- Telephone Survey
- Follow-up mailing
- Visits to selected laboratories



A SOCIO-ECONOMIC AND ENVIRONMENTAL INVENTORY OF THE NORTH ATLANTIC REGION

**TRIGOM
PARC**

FIGURE
1-2

Task Descriptions (TRIGOM, 1973a)

Approach

A large number of contacts were made in each state at agency, institutional, and federal levels as well as in Washington to identify ways to access data banks, on-going research programs, and bibliographic sources.

Methods

Telephone/Letter Survey: During the course of the study approximately 230 contacts were made through a telephone survey to obtain environmental data and information about related programs. A separate effort of requesting reports or data sources by mail was also conducted, as well as a routine mail follow-up to initial telephone contacts. A study abstract was included in any written request or follow up to briefly summarize the BLM program needs. The reverse side contained a map. An example is shown in Figure 1-3.

Field Visits: In cases when information was too extensive or in an uncompiled form TRIGOM sent data specialists to visit and obtain what was needed. About 95 visits were made between July, 1973, and April, 1974, by staff and consultants. A complete list of visits, agency/facility name, and persons contacted can be found in Appendix B.

Literature and Research Services: Use was made of the Smithsonian Science Information Exchange (SSIE) listing service of ongoing research projects. Two searches for all states in the study area produced about 250 notices (Appendix C-2 presents all relevant research notices arranged by state). As a follow-up, cards were sent to each principal investigator listed, requesting information and recent publications. Approximately 15 percent of the requests produced replies with papers. However, we note that replies continue to arrive some five to six months after the initial request.

Also used was the National Technical Information Service (NTIS). A listing of all relevant annotated bibliographies received for all topics in the study is presented in Appendix D. A total of 305 were reported. Although NTIS has over 300,000 listed citations in their system since 1964, the rather meager number of 305 appears to be only a minor portion of the total publications in the open literature and is probably not representative.

Similar requests for bibliographic citations or inventory data were made at this time to National Oceanographic Data Center (NODC), Environmental Protection Agency (Headquarters and Region I), NOAA, National Marine Fisheries Services; and NOAA's MESA, New York Bight Program, and the U.S. Army Corps of Engineers. A more complete description of the results and an evaluation of these efforts in relation to this study

TRIGOM

The Research Institute of the Gulf of Maine

96 Falmouth Street
Portland, Maine 04105
Tel. (207) 773-2981

Figure 1-3

A SOCIO-ECONOMIC AND ENVIRONMENTAL INVENTORY
of the
OUTER CONTINENTAL SHELF AND ADJACENT WATERS
A Study by
The Research Institute of the Gulf of Maine

ABSTRACT

Background

The nation recently has focused its attention on the potential sources of clean energy suspected to lie beneath its continental shelves. With the possibility of inadequate supplies of energy, we now are beginning to investigate sources off the New England coast. Prior to leasing and developing any of these offshore areas we must have sufficient environmental, social, and economic data to aid in the decision process. TRIGOM has been awarded a contract by the Bureau of Land Management of the Department of Interior to undertake a one-year study to collect and assemble all relevant data for the North Atlantic outer continental shelf from the Bay of Fundy to Sandy Hook, New Jersey.

Objectives

The study objectives are to develop a comprehensive inventory of marine environmental data and related socio-economic factors for the coastal zone and outer shelf areas. The inventory will be designed to aid in gathering data to assess the impact of the development of energy resources and define areas where no relevant data exist.

The following list is a summary of the topic areas in which data, published and unpublished reports, and ongoing research are sought:

PHYSICAL ENVIRONMENT: Estuaries, tides, waves, hydrography, currents, temperatures

CHEMICAL OCEANOGRAPHY: Oxygen, nutrients, heavy metals, organic pollutants

GEOLOGY: Regional, bathymetry, structure, sediments

METEOROLOGY: Atmospheric circulation, climatic elements, air-sea interaction

SYSTEM ECOLOGY: Phytoplankton, zooplankton, benthos, fisheries, marine mammals, birds, coastal vegetation

UNIQUE AND ENDANGERED ENVIRONMENTS

INDUSTRIAL AND COMMERCIAL ACTIVITY: Resource, manufacturing, service industries

PETROLEUM INDUSTRY

DEMOGRAPHY: Population, income and employment, education and job skills

LAND AND WATER USES

POLLUTION SOURCES

TRANSPORTATION SYSTEMS

The TRIGOM study team is a three-part group composed of TRIGOM staff, the Bowdoin College Public Affairs Research Center, and the University of Rhode Island. For further information, contact: TRIGOM, Dr. Donald B. Horton or Ned Shenton (207) 773-2981 extension 306; Bowdoin (PARC), Mr. Carl Veazie (207) 725-8731 extension 591; University of Rhode Island, Dr. Saul Salla (401) 729-6239.

is given in Appendix A.

TASK 3: DATA REDUCTION

- Assemble initial bibliographies
- Collate data from field visits
- Assign chapter and topic authors
- Develop and organize report outline

Approach

During this task, we attempted to bring together the first results of the literature collection, the visits to facilities, and other inputs received. Specific topic areas such as marine geology, chemical oceanography, etc., were assigned to chapter authors. A full list of the topical areas and authors assigned is given in the acknowledgement section, and the subject is discussed further under 1.5 Organization of the Report. In general, our basic approach was to organize the study by natural habitats as defined by Odum et al. (1969) and others, rather than following the conventional topical approach.

A second aspect of this task was a redefinition of the report outline. This was necessary as a result of the decision to adopt the habitat versus topical approach, and also as the specific requirements for impact analysis were defined. (See Methods below).

Methods

Assigning Chapter Authors: A number of scientists who had recently contributed to the writing of the Coastal and Offshore Inventory of Cape Cod to Cape Hatteras (URI, 1973 and 1974) were retained to either be reviewers or contribute a portion covering the southern extent of the study area. Other professionals within the study region were contracted for specific chapter treatments.

Coordination of Authors: A considerable effort was required to coordinate the efforts of authors whose sections were closely related. TRIGOM staff assumed this responsibility, but were hindered to some extent by the large number of authors situated at some distance from one another throughout the study region. A good interchange of data did result in some cases, an example being among the estuarine dynamics, physical oceanography, and meteorology authors. There was also a similar exchange of data between the PARC - URI economics group and the marine environmental scientists.

Data Retrieval: TRIGOM staff continued to acquire data and supply information to the chapter authors not easily obtained or available in the published literature. Data retrieved from facility visits were reviewed and where necessary, second or third trips made. Reports were received and accumulated, a bibliography was constructed, arranged by topic area, and periodically distributed to chapter authors.

Refinement of Information Needs: To make sure that our topics selected on the proposal and subsequent negotiations were complete and adequate for the anticipated activities both offshore and onshore, we reviewed several current Environment Impact Statements. Among these were several documents by BLM (1973) for the Gulf of Mexico, and the U.S. Army Corps of Engineers (1973), also in the Gulf of Mexico. From this review, a matrix was developed (Table 1-3) which enabled us to see additional environmental topics that should be emphasized including some of the socio-economic factors. As a result, an adjustment was made to the initial topics to be inventoried, for example, by adding hydrology and water resources data and solid waste considerations.

Review of Chapters: Finally, the submitted environmental sections prepared by consultants were reviewed for general accuracy, comprehensiveness, and over-all scientific quality. In many cases, these reviews were made by outside independent consultants.

TASK 4: SYNTHESIS OF DATA AND FINAL REPORT

- Distribute report outline
- Conduct program review
- Prepare final report

Approach

The intent was to develop an outline of topics early in the program and continue to update, improve, and add to it along the way. Toward the completion of the project, we had planned to conduct a one-day review of the program using an advisory board. This review committee would act as a steering body for the final report.

Methods

The outline of all topics to be inventoried was issued in the fourth month and reviewed and revised monthly so as to include topics and information discovered or decided to be of importance to the study. Although it became impossible to conduct a review (advisory board) on the entire study, a one-day review was held of the socio-economic report in April.

Table 1-3: Data Needs Matrix

<u>ACTIVITY</u>	<u>DIRECT EFFECTS</u>	<u>PARAMETER IMPLIED</u>
1. Dredging and Spoil Disposal 1/	<ul style="list-style-type: none"> a. habitat loss b. destruction and loss of resident biota c. interference with ground water quality and quantity d. salinity intrusion e. turbidity f. alteration of natural current and wave patterns g. contamination of dredged area and disposal site with toxic elements in sediments 	<ul style="list-style-type: none"> a. habitat inventory (% loss over time, history of endangered environments-i.e., wetlands) productivity index of habitats b. inventory of biota by habitat and notation of those species endangered or threatened c. water table contours and quality, identification of major aquifers d. estuarine salinity profiles, gw contours e. delineation of bottom sediments; current levels of turbidity and current sources of sedimentation, current O₂ profiles f. definition of present current and wave patterns g. inventory of sediments - source, origin, age; sedimentological parameters (texture, heavy minerals, toxins)
2. Construction of Pipelines 1/	<ul style="list-style-type: none"> a. disruption of bottom habitat - open ocean b. turbidity - open ocean c. disruption of drainage systems in wetlands d. destruction of marsh vegetation e. loss of habitat f. erosion 	<ul style="list-style-type: none"> a. same as (a) and (b) above b. temporary effect; dependent on type of sediments and current sediment levels c. watershed drainage systems d. inventory of unique or endangered vegetation e. inventory of habitats and ecosystems f. topographic contours, soil maps

3. Supertanker
Operations 1/

- | | |
|---|--|
| a. increased turbulence, scouring and wave generation causing erosion and sediment transport, and increased turbidity | a. channel depths, composition of sediments, existing turbidity levels, existing O_2 levels |
| b. increased navigation hazard | b. level of use by small crafts; incidence of accidents in past |
| c. spillage of oil causing <ol style="list-style-type: none">1. damage to beaches, recreation impacts, mollusc damage, destruction of bird nesting habitat2. damage to estuaries and their ecosystems3. damage to marsh vegetation and soil erosion4. destruction of species - decreased species diversity (toxic effects to organisms)5. disruption of feeding or breeding or other behaviors of birds and mammals and other key species6. sublethal damages to organisms | c. <ol style="list-style-type: none">1. Beach inventory<ul style="list-style-type: none">-level of recreational use-extent of clam and mussel flats-definition of wildlife habitats and species nesting in intertidal zone2. estuary inventory - description of ecosystems and key species including shellfish and fin-fish larvae3. wetlands inventory - type of plants and soil (relative tolerance to oil pollution)4. species diversity indexes - areas already stressed, areas of high quality, areas marginally stressed, tolerances of key species, trophic diagrams5. life histories of key species6. life histories of key species (life span, productivity, incidence of disease, etc.) |
| d. oil spillage - nature of damages variable according to physiography, hydrography, weather conditions | d. physiography
hydrography
weather conditions |

1/Note: Activity and Direct Effects information taken from the Corps of Engineers Report on Gulf Coast Deep Water Port Facilities - Vol. IV, Appendix F. 1973

4. Platform Construction 2/

- a. turbidity
- b. bottom habitat loss
- c. new habitat loss
- d. visual disruption
- e. navigation hazard

- a. bottom geology
- b. habitat inventory, species inventory
- c. predictive analyses
- c. delineation of recreation areas and distance within line of sight
- e. level of shipping and commercial fishing traffic, and routes

5. Drilling Operations 2/

- a. turbidity from offshore disposal of drilling muds
- b. loss of bottom habitat from disposal of drilling cuttings
- c. change in salinity in area around drill rig from disposal of formation waters (brines)
- d. burden on onshore waste treatment or disposal systems in areas adjacent (or on offshore disposal areas if available) from solid wastes; and oil or acid contaminated waters

- a. habitat and species inventory
- b. habitat and species inventory
- c. life histories of species in pelagic and offshore bottom habitat - tolerances to changes in salinity
- d. availability of waste disposal sites - onshore and offshore

6. Construction of Onshore Storage Facilities 3/

- a. loss of available land (possibly wetlands)
- b. when wetlands filled or drained, lowering of water table, release of organic nutrients to surrounding waters, loss of natural buffer to wave and wind erosion, possible contamination of groundwater; loss of fish and wildlife habitat

- a. land use inventory (especially wetlands)
- b. delineation of aquifer systems; definition of existing stresses or water quality; list of species in salt marsh habitat - especially those endangered or threatened

7. Construction of Refineries and Petrochemical Complexes 3/

- a. increased air and water pollution loads
- b. loss of lands

- a. existing air and water quality conditions - needs of refineries and petrochemical complexes
- b. same as for storage facilities

7. Cont.

c. demands on water supply

c. water supply capabilities

d. demands on electric power

d. power generation sites and capacities

8. Construction and
Operation of Drill
Rigs, Storage Faci-
lities and Refinery
Complexes 3/

a. demands on labor force - both
temporary and permanent

a. labor force statistics

b. increased income and tax base,
overtime

b. total earnings/cv

INDIRECT OR INDUCED EFFECTS

a. demands on housing - increased
rents; increased use of marginal
units

a. cost of living index for the area; housing
starts/yr

b. demands on municipal services -
schools, hospitals, garbage collec-
tion, sewage treatment, transporta-
tion, power, etc.

b. excess capacity of existing services - or excess
demand

NOTES: 2/ Activities and Direct Effects taken from BLM Draft Environmental statement, Proposed 1973 OCS Sale No. 32, p. 21

3/ Activities and Direct Effects taken from both Corps and BLM reports, and additional sources

Review of the environmental inventory was conducted on a chapter-by-chapter basis, as described above. Thirty authors were involved in the writing of that volume.

1.5 ORGANIZATION OF THE REPORT

This report has been organized to provide inventory type data by topic area and by regional habitat area as well. The guiding philosophy of the study organization and the subsequent report has been to emphasize systems ecology in the environmental chapters. This approach is discussed in greater detail in the Regional Overview, Chapter 2.4, Biology.

In a simplified way, we have attempted to organize the report by major habitats such as Offshore Region, Major Sounds and Embayments, Exposed Shorelines, and so on, rather than by the more traditional scientific discipline (i.e., physical oceanography, geology, biology, etc.). This integrated approach we believe is important in understanding the functions and dynamics operative with a distinct region, and is based on extensive work in Systems Ecology by Odum (1969) and others. We have, however, added descriptive sections on the major plant and animal groups.

Therefore, we have first tried to view the total setting of the study area in the Regional Overview. These sections give a broad background of geology, meteorology, hydrology, biology, and chemical oceanography prior to considering each separate habitat and following that, each taxonomic group of organisms (e.g., phytoplankton, etc.)

The basic arrangement of the final report is into three volumes. These are the (1) Environmental Inventory and Assessment, (2) Socio-Economic Factors, and (3) Appendices. Within Volume One, there are several books. The Table of Contents of the report shows the major breakdown of chapters and topics. In summary this is:

Volume One	Environmental Inventory
Book one	
Chapter	1. Introduction
	2. Regional Overview
	Environmental Systems
	3. Offshore Region
	4. Major Sounds and Embayments
	5. Exposed Shoreline
	6. Shoreland Strand
	7. Upland Environments
Book two	Plant-Animal Profiles
	8. Phytoplankton
	9. Zooplankton

10. Benthic Invertebrates
11. Macrophytes
12. Fishes
13. Birds
14. Mammals

Other Environmental Aspects

15. Unique, Significant and Endangered Environments
16. Rare, Threatened, and Endangered Species
17. Environmental Quality

Volume Two

Socio-Economic Inventory

- Chapter
18. Introduction
 19. Demography
 20. Economic Overview
 21. Petroleum
 22. Recreational Activity
 23. Transportation
 24. Other Marine Activities
 25. Fisheries
 26. Land and Water Use
 27. Summary and Recommendation

Volume Three

Appendices to Volume One

- A. Additional Data Sources
- B. Contacts
- C. Ongoing Research
- D. Bibliography
- E. Areal Extent of Habitat
- F. Contract

1.6 LIMITATIONS

In a study such as the present one, which has at once an enormous scope and an all too limited time allowance for preparation, it is only understandable that there may be a number of distinct limitations placed both on the contract group and on the resulting product.

Briefly, we will try to list the areas in the study where problems in the approach, the results, or the lack of definition make the report less than might be desired. This is not meant to be an excuse for performance or a criticism of anyone's shortcomings; it is merely a statement of fact.

LIMITATION NO. 1: UNCERTAINTY OF PURPOSE

The present study was for the most part built around the RFP, and initial

outline proposed by TRIGOM, a series of conversations with BLM personnel, and the specific requirements of the CEQ/MIT task. The basic intent was a broad inventory of a large list of diverse topics. There was for a considerable time some uncertainty as to the purpose of the inventory. As a result, it was difficult to define what elements of the study were most critical and which were irrelevant.

LIMITATION NO. 2: FOCUS: OVERALL REGION OR SITE SPECIFIC LOCALITY

Since there was an uncertainty here too, general direction was given that the socio-economic inventory was to be general with data aggregated at the county level, not site specific. The environmental side was directed toward comprehensive treatments rather than voluminous aggregations of detailed data, with a proviso to include occasional detailed studies where pertinent. As a result, the report is limited.

While it may aid in the preparation of site specific studies or EIS's, it is doubtful, since the effort has been to uniformly cover some 6,000 miles of coastline and all the offshore areas, that enough detail exists on which to base a site specific statement. This conclusion will be developed and supported in more detail in Chapter 27, Summary and Recommendations.

LIMITATION NO. 3: TIME CONSTRAINTS

A period of ten months was allowed to conduct the study. This is hardly adequate considering the steps involved: formulating an approach, collecting the data, assembling the pieces, and writing comprehensive sections (some possibly for the first time). It was an uncomfortably short time to attempt such an all-inclusive work. It is reasonable then to say that it is at best a first approximation, and cannot be considered complete, exhaustive, thorough, or the like. Any attempt to imply that these are all the pertinent data would be incorrect.

This is especially so for the life history data for the "key species." By stating "no information" we are saying that no data were readily available within the period of time allotted or at the particular library used. It is likely that somewhere data may be available.

LIMITATION NO. 4: DATA CONSTRAINTS

Certain portions of the data we have collected are the most recent and best available at this time, but very likely will be changed or improved within a year or two. Such parameters as air and water pollution data, land use information, economic factors, and so on, could change significantly and need re-examination. Each element should therefore be examined for its value in future use. In addition, a number of data

bases (wetlands inventories, economic evaluations, marine resource analyses, recreational estimates) are already outdated, some being at least 10 years old. In such cases, data must be regarded as indicative only, and serve as example of the types of data necessary for future considerations.

1.7 ACKNOWLEDGEMENTS

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Geology

South of Cape Cod	Dr. John Milliman	Woods Hole Oceanographic Institution
Gulf of Maine	Dr. Harold Palmer	Severna Park, Maryland
Beaches and Estuaries	Mr. Barry Timson	Maine Bureau of Geology

Physical Oceanography

Northern Region	Dr. Joseph Graham	Maine Department of Marine Resources
Southern Region	Dr. Barbara Welsh	University of Connecticut, Marine Sciences Institute
	Ms. Janet P. Herring	University of Connecticut, Marine Sciences Institute

Chemical Oceanography

Dr. Ted Loder	University of New Hampshire
Mr. Tom Shevenell	University of New Hampshire

Meteorology/Climatology

Dr. James Havens	University of Rhode Island
Mr. Ed Levine	University of Rhode Island
Dr. David Shaw	University of Rhode Island

System Ecology

Mr. Stanley Chenoweth	Boothbay Harbor, Maine
Dr. William Gilbert	Colby College
Dr. Mary Gilbert	Colby College

Phytoplankton

Dr. Hugh Mulligan	University of New Hampshire
Ms. Frances DeLara	University of New Hampshire

Zooplankton

Dr. Donald B. Horton	TRIGOM
Mr. William Johnson	University of Rhode Island
Mr. Paul Reilly	University of Rhode Island
Mr. Bruce Rogers	University of Rhode Island

Benthic Invertebrates

Mr. Alden Stickney	Maine Department of Marine Resources
Dr. Peter Larsen	Maine Department of Marine Resources
Mr. Sheldon Pratt	University of Rhode Island

Macrophytes	Dr. Alton Gustafson Dr. Barbara Heavers	Bowdoin College University of Rhode Island
Fishes	Mr. Stanley Chenoweth	Boothbay Harbor, Maine
Birds	Dr. Frank Heppner Mr. William Townsend Ms. Lisa Gould	University of Rhode Island Sorrento, Maine University of Rhode Island
Marine Mammals	Dr. Steve Katona Ms. Kate Darling Mr. David Richardson	College of the Atlantic College of the Atlantic Marine Department of Marine Resources
<u>Population and Income</u>	Dr. Kenneth E. McConnell	University of Rhode Island
<u>Overview of Economic Activity Transpor- tation</u>	Mr. Carl E. Veazie	Public Affairs Research Center, Bowdoin College
<u>Petroleum-Petrochem- icals</u>	Dr. Thomas Grigalunas	University of Rhode Island
<u>Other Marine Activities</u>		
<u>Recreation</u>	Dr. James W. McFarland	University of Rhode Island
<u>Fisheries Economics</u>	Dr. Gerald R. Visguillio	Connecticut College
<u>Land Use</u>	Mr. William MacDonald	Winthrop, Maine
<u>Maine Rivers/ Water Research</u>	Mr. Richard Harvey	Scarborough, Maine

Other Contributors Mrs. Jean Chenoweth, Mr. Herbert Perkins, Ms. Lee Perkins, Dr. Robert Knowlton, Mr. Diego Alonso, Ms. Nora Cippola, Robbin Hazard, Steve Burke, Steve Reinert.

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State

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Maine Department of Marine Resources, Boothbay Harbor, Maine
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Private and Regional

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New England Regional Commission
New England River Basins Commission (NERBC)

For a listing of all individuals contacted at these and other agencies, please consult the Directory of Contacts, Appendix B.

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TRIGOM staff

Ms. Diane Brackett - Data Analyst and Archaeology

Mrs. Ruth Brown - Administrative Assistant
Ms. Barbara Caminiti - Secretary
Mr. Terry DeWan - Drawing Coordination and Production
Mrs. Nancy Goodspeed - Typist
Ms. Shirley Griffin - Habitat Mapping, Rare and Endangered Species
Ms. Betsy Holloway - Assistant
Dr. Donald B. Horton - Executive Director of TRIGOM and Zooplankton
Ms. Kathy Sage - Water Resources, Pollution Data, Endangered Environments
Mr. Edward H. Shenton - Program Manager
Ms. Judy Stanhope - Drawing Coordination

PARC Staff and Consultants

Dr. Thomas A. Grigalunas - Assistant Professor, Resource Economics, University
of Rhode Island
Mr. William E. MacDonald - Planning Consultant
Dr. Kenneth E. McConnell - Assistant Professor, Resource Economics, University
of Rhode Island
Dr. James W. McFarland - Assistant Professor, Resource Economics, University
of Rhode Island
Mr. Carl E. Veazie - Director of PARC, Bowdoin College
Dr. Gerald R. Visguillio - Assistant Professor of Economics, Connecticut College
Ms. Johana Williams - PARC, Bowdoin College

Additional typists were:

Ms. Dee Ann Lamb - University of Rhode Island
Ms. Claudia Foret - University of New Hampshire
Ms. Elizabeth Masciadri

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- University of Rhode Island (URI), Marine Experiment Station, Graduate School of Oceanography. 1973. Coastal and offshore environmental inventory, Cape Hatteras to Nantucket Shoals, Marine Publications Series No. 2. URI, Kingston, Rhode Island. 681 pp.
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Chapter

27 Environmental Data Gaps and Research Needs

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27.0 ENVIRONMENTAL DATA GAPS AND RESEARCH NEEDS

27.1 INTRODUCTION

The following suggestions to fill in data gaps by no means imply that all items must be gathered prior to OCS leasing activities. The questions of whether certain data are needed for such leasing decisions are beyond the scope of this study. We have assembled these sections as a brief review of the coverage and adequacy of the data collected in the environmental chapters 2.0 to 17.0. In addition, we asked each chapter or section author to describe future research needs to fill in these gaps or deficiencies as well as to indicate any priorities he believes should be given to this work. Instructions for this task are shown in Figure 27-1, Memo-randum to All Section Authors.

The majority of the data collected and resulting written statements are fairly general by the very necessity of covering such large coastal and offshore regions. It is obvious that in many areas more data exist but that the inclusion of these would have been inappropriate for a regional study of this type, as well as requiring more time than that available. In other cases there may be no additional data that would be meaningful. As an example we cite the area of physical oceanography. It is a near certainty that no more extensive or detailed current and circulation data exist for the Gulf of Maine or bordering near-shore areas; however, one might be able to assemble vast amounts of temperature data over long periods for scattered areas. It is doubtful that these data would be useful for the present study.

So, while we have presented only contours of temperature on a seasonal basis, there would be little value in capturing and presenting any additional data from other sources.

On the other hand, once a specific site is selected, we may wish to obtain new temperature data to permit estimates of circulation, discharge, flushing rates, and so on.

What we are concluding then, is that until more specific plans are formulated for development, with the suspected resulting impacts, we can at best only recommend broad additions to existing data on the basis of our present understanding or lack of understanding of ultimate needs resulting from the intent to develop the OCS.

The following discussion treats the gaps and needs by discipline, since we tend to orient our thinking and research planning in this manner rather than by the basic orientation of the report into bio-geographic

MEMORANDUM SENT TO ALL AUTHORS

MEMORANDUM

TO: All Section Authors

FROM: E. H. Shenton, TRIGOM

SUBJECT: Conclusions of BLM Draft Report: Data Gaps and Deficiencies

A final task that we have put off until this stage is attempting to assess any information or data which are missing. We need each author's help in this assessment.

The exact wording of our contract stated:

"Define the gaps and deficiencies that exist in the present information baseline that is preliminary to conducting field research and new surveys, and (provide)

"A discussion of environmental information still needed to fully assess the impact of leasing activities and development of energy and other resources in the study area."

In assessing what is needed and the uses of our data base, there are three suggested purposes to be considered: (1) Environmental impacts resulting from OCS leasing; (2) planning for OCS leasing at a regional scale and (3) planning feasibility of coastal development.

Work Statement:

1. Define areas of coverage where there are data gaps or deficient data to meet the above purposes. A brief paragraph should be written on each item with an evaluation of what we now know (i.e., sediments, structure, temperature, or whatever the key elements of your report are).

2. List with brief explanation the priorities of research needed in attempting to assess the impact of OCS activities.

Don't worry about how data are to be collected, such as sampling rates, frequency, station spacing, money or time needed to conduct a survey. This will come later. We have proposed to BLM to convene a small closed session later this summer to deal with "how it's done."

A SOCIO-ECONOMIC AND ENVIRONMENTAL INVENTORY OF THE NORTH ATLANTIC REGION

TRIGOM
PARC

FIGURE
27-1

MEMORANDUM SENT TO ALL AUTHORS

habitats. The order follows the general order of the report which is: geology, physical oceanography, chemical oceanography, and so on.

27.2 GEOLOGY INCLUDING CHAPTERS 3.1, 4.1, 5.1

OFFSHORE NEEDS: CHAPTER 3.1

The needs in furthering our geological knowledge of the offshore region from Maine to New Jersey, especially in the Gulf of Maine are two-fold: more complete insights into the structure, stratigraphy and history of the area, and two, better knowledge of the processes which affect the sediments and morphology of the modern shelf.

- (1) Structure, Stratigraphy, and History. In order to understand this aspect of the Gulf of Maine region better, we need more complete and sophisticated geophysical data. This would include more accurate magnetics (preferably aeromagnetics at 1 to 2 gamma intervals), gravity data (which are sadly lacking over much of this area), and more sophisticated seismic profiling, such as multichannel data. At present, the available data have been used by Ballard in his thesis (1974), but other data have been kept confidential by petroleum companies. Aeromagnetic and multichannel seismics at this stage are only becoming possible for oceanographic institutions and universities, and it probably will be at least several years before the equipment can be used extensively and reliably on the U. S. continental margin. On the other hand, the U. S. Geological Survey is presently tooling up for such an operation, and probably will be obtaining this sort of information within the next year or so.

Without having stratigraphic control, the interpretation of geophysical data is at best questionable. Yet, the control used in making the interpretations given in the offshore geology chapter is very scattered, consisting of logs from a few scattered offshore drill holes and dredgings from a number of canyons. At least 10 to 20 drill hole sites, spaced over primarily the outer shelf, with others also over areas with potentially thick sedimentary sequences (such as the Baltimore Canyon Trough), should be drilled. Many of these may be drilled in the summer of 1974, if permission is granted the U. S. Geological Survey. Some holes can probably be relatively shallow, but at least some should penetrate several km, and possibly one could extend more than 5 km.

- (2) Shelf Processes. The need for these data stems not only from our desire to understand the physical controls upon shelf processes, but also the more applied need to document these areas with respect to baseline data, so that the environmental impact of economic utilization of the offshore area will be understood and predictable. What effect would an offshore structure have upon the surrounding bottom? How would an oil spill affect the bottom?

sediments? How deep should a pipeline be laid-under the bottom sediments? How will offshore mining affect both the bottom sediments and the suspended matter regime? These and other questions must be answered before economic exploitation can begin.

Most of our insights into shelf processes come from our knowledge of the distribution of sediments and morphological types. But clearly, opposite must also hold: if we want to understand the morphological and sedimentological control on the shelf, we must understand the processes. The ideal way to study the processes on the shelf is to study a number of small areas, each of which would be representative of a larger morphologic and sedimentologic unit. For instance, the study of the current, temperature, and suspended regime within several of the Gulf of Maine basins probably could serve as a preliminary model for our understanding of basin processes. Similarly, the current, hydrography, and small scale morphologic changes (such as migration and sand waves) would help in understanding the environments of Georges Bank, Nantucket Shoals, and several other areas that presumably have active bottom environments. Several observations are basic: first, the small scale morphology of the area (in terms of meters or decimeters) throughout the year; this would thus define the stability of the area. Is it stable, in continual motion, or does it move only during major storms? Second, we would need to monitor the current regime of the area by emplacing a series of bottom-mounted current meters. Third, the suspended matter and bed-load regime probably could best be measured using recording photographic methods, controlled by sporadic sampling of the environments. These measurements should be taken at relatively closely spaced intervals (at least once every 6 weeks, or maybe even more frequently) throughout the year, for a minimum of two years. Also needed is a study of the shallow stratigraphy of the area, since this would also allow us better prediction into the effect of offshore structure construction upon the stability of the bottom, as well as measuring the distribution of sedimentological properties in the various areas. At present, our sample coverage in most areas is 1 sample every 259 km². Clearly, a much better knowledge of the sediments of any particular area should be gained before economic exploitation begins.

COASTAL NEEDS: CHAPTER 4.1

The needs for further research in coastal areas with respect to geology mainly concern the movement of sediment and the impact of man's activities upon that movement and upon the quality of the sediment itself. We have seen in the major sounds and embayments how the construction of man-made structures can affect the equilibrium of a beach of embayment. As the coastal zone is increasingly utilized, our knowledge should come increasingly from predictive abilities, not from hindsight as it has in

the past.

- (1) Sediment Movement. How does sediment move in the nearshore areas? Does it move into estuaries from the sea or does river-deprived sediment pass through the estuaries on its way to the sea? Presumably, the former case appears to hold for most estuaries throughout the east coast, and yet, our observations on the suspended and bed loads of estuaries are extremely poor, particularly during the stormy winter months, when probably much of the transport occurs. Similarly, the operation of sedimentary processes on beaches and islands is generally known (see the Beach, Chapter 5.1), but specifically too little is understood. What are the long-term trends of various beaches? What are the sources of sediment and what processes control these parameters?
- (2) Man's Impact. We have seen that man's activities, from dredging to duck-farming to industrialization to jetty construction have materially affected the coastal zone environment, and yet the predictive studies on such impacts are sadly lacking. In most cases we use actual impact results rather than predictive studies, but by this time the damage has already been done. How much pollution can be put into a coastal area without deterioration of that environment? Obviously, the answer depends upon the specific area (beach, estuary, or whatever), as well as what pollutant which is introduced. Predictive models should be encouraged, and the data needed to construct such models should come from both available data and that gathered from studies mentioned in the preceding paragraph.

LIMITATIONS OF BEACH DATA: CHAPTER 5.1

Geologic processes of numerous small beaches and several larger strands along the New England shoreline have not been studied. These should be given a reconnaissance before offshore oil production activities commence.

The longest portions of beaches remaining unstudied are the eastern and southeastern shorelines of Cape Cod Bay. Little or no data exist for the eastern beaches; and, although Nilsson (1972) worked on the intertidal swash bar complexes typical of the southeastern areas, only grain-size data and a few profiles are documented. However, Nilsson failed to note the importance of the post-storm accretion processes and the relationships between beach state and swash bar migration rates and characteristics.

Chute and Segerstrom (1949) have studied the beaches of the Plymouth-Duxbury, Massachusetts region, but we could not obtain a copy of their work to review. Review of this work, and perhaps further study of these beaches, is critical because of the location immediately down

drift of Boston Harbor.

The coastline of New Hampshire has been studied superficially in regard to beach processes. Most of these beaches are gravel; the process of gravel beach behavior is least well understood. In addition, the location close to a potential tanker terminal location in or near the Piscataquis River estuary demands that these beaches receive considerable attention before petroleum product activities begin.

Only a few Maine beaches north of Portland have been studied at the present time, although many of these beaches are heavily used for public recreation areas. Also, pocket beaches occur in Maine, but these are too numerous to be studied individually prior to proposed offshore activities. Several representative pocket beaches should be selected and studied, along with the Popham and Reid State Park beaches.

Data Lacks with Respect to Oil Pollution of Beaches. Effective removal of spilled petroleum from beaches before extensive weathering and ecological damage occurs should be the primary objective of any spill clean-up program. Little or no research concerning the effects of beach processes on efficient removal of oil exists along the New England coastline because of the infrequency of spills, the small size of spills, or the lack of research or observations during spill clean-up.

There are several areas of research needed to understand the efficiency of beach clean-up with minimum environmental effects. These areas focus on understanding long and short-term changes in beaches and barrier beaches, processes on gravel and low-energy beaches, time and space relationships between beach sediment sources and delivery to the beach system, and the relationships of offshore bars to the subaerial beach.

Present techniques for removal of hydrocarbons from beaches are basically limited to absorption of surface patches or globules to a disposable material such as straw. In some cases where clean-up operations have been delayed, oil has saturated the beach sediment to depths up to 15.2 to 20.3 cm (Tamano Spill, Portland Harbor, 1972). Thus, to remove the toxic hydrocarbons, substantial quantities of beach sediment are also removed. The question arises, what are the effects of removal of large volumes of sediment on various types of beaches? What are the beach processes which would prevent rapid removal of surface oil before it becomes leached to depths below the beach surface? For answers to these and other similar questions on the effects of oil on beaches more specific research is needed.

We know too little about long-term barrier beach processes and equilibrium in New England. We should investigate short-term drift processes and rates for representative beaches. Included should be empirical

studies to predict longshore drift using tracer sands under different wave climate conditions to help us derive predictive equations.

Another topic for research is the barrier systems off the beaches. The effects of removal of substantial quantities of sand from the barrier system on the immediate area and the beach system as a whole are not known. What are the rates of beach recuperation? What are the effects of removing sand on the source supply - transport system? Further, what is the response of offshore bars to onshore sand removal? Sand from offshore bars may naturally replace removed sand, but this process may lessen the offshore bars' effectiveness to protect the subaerial beach from storm wave erosion.

Coarse-grained beaches (gravel and mixed sand and gravel) respond quicker to climatic variables than do finer sand beaches. The high porosity and permeability of these beaches will impede surface clean-up and necessitate removal of coated beach sediment. Research is needed to understand the processes of these beaches, their post-storm recovery rates, their relationships to either upland or offshore sediment supply sources, and their role in protecting backbeach areas.

Low energy beaches are sheltered from vigorous wave activity and thus are characterized by a sediment-size distribution reflected in their adjacent upland source material. They are generally coarse-grained and protect the base of upland scarps from erosion. Their response to wave climate changes and their role in maintaining upland slope stability should be determined to understand the effects of sediment removal to recover spilled petroleum.

LIMITATIONS OF ESTUARINE DATA

While geologic and hydrographic studies have been conducted for most New England estuaries, flushing rates have been determined for very few. Preliminary rates should be determined for those estuaries having river flow data associated with them from hypsographs constructed with the aid of coastal charts.

Because there are so many estuaries in Maine, these are perhaps the least studied. The Kennebec River estuary, although one of the major waterways, has probably received little attention. This complex estuarine basin should be studied hydrologically because of its size, complexity, and possible proximity to petroleum handling facilities.

Other Maine estuaries lying east of the Penobscot River need further investigation prior to locating port facilities associated with offshore activities.

Little is known about the effects of oil spills on the sediments of estuaries or even the transport of oil slicks into restricted estuarine

embayments.

Slick transport into coarse-grained estuaries should be simulated to determine the extent of possible pollution from spills external to the estuary. Spills from within the estuary should be documented to determine the processes resulting, as well as the relationship of spill removal rates to determine flushing rates of the basin.

The removal of substantial volumes of sediment from coarse-grained and fine-grained estuaries may result from oil spills or harbor dredging. Will the removal of this sediment effect the estuaries' substrate elsewhere in response? Studies of estuarine morphology interrelationships are needed to understand these possible changes. As an example, considerable morphological changes have occurred in dredging the coarse-grained estuaries of Wells Harbor, Merrimack River estuary, Scarborough estuary, and the Saco River estuary.

Also, these activities have adversely affected neighboring beach sediment supplies. The role of coarse-grained estuarine morphology, sediment transport equilibrium, and inlet dynamics to beach sediment supply must be studied and better defined.

Sedimentation processes in fine-grained estuaries are poorly understood, not only locally, but on a world-wide basis. These processes include the mechanics of flocculation, the relative amounts of suspended sediment derived from fluvial sources versus oceanic sources, and resuspension and resedimentation of fine-grained sediments by benthic organisms, currents, and waves. Problems of this nature can only be resolved by long-term research. Related, but of a more immediate short-term consideration, is the relationships plankton organisms to flocculation sedimentation to determine the effects of oil pollution on zooplankters, and thereby on estuarine sedimentation.

Finally, in needed research on fine-gravel estuaries, the effects of channel or mooring space dredging on sedimentation in estuaries has received increased attention because of environmental concern. Specific studies should be designed to sufficiently determine dredging effects on estuarine morphology and the possible changes that may result. These should be done well in advance of specific dredge projects connected with harbor activities.

27.3 PHYSICAL OCEANOGRAPHY CHAPTERS 3.2, 4.2, 5.2,

OFFSHORE

- (1) Detailed measurement of temperature, salinity, and currents. We presently have a general understanding of the distribution of these variables but only on a broad and seasonal basis. Large

gaps in areas and time spans exist. What is needed is more detail over a more continuous period to be able to understand the variable distributions within smaller areas and over short periods of time, that is, if we need to be able to come closer to predicting the distribution over short time spans. This requires more detailed measurement of velocity and direction of water movement within segments of circulation. There are extremely few reliable measurements of current transport in the open Gulf of Maine or over Georges Bank.

- (2) Circulation in Basins. Relatively little work has been done to determine circulation and exchange within the deeper basins of the Gulf of Maine. It is likely that over periods of 20 years that these basins receive and collect considerable accumulations of foreign or toxic materials brought in from outside sources. The exchange rate and renewal of these basin waters is not well known. The periodic, occasional, or only random flushing of these waters should be determined to understand better what may occur if there is either continuous, occasional, or no exchange of waters from the basin sinks.

A second part of the circulation task is to develop more predictive models of surface currents to simulate the distribution of waterborne products. This modeling should also look into verticle products in the water column in this direction.

- (3) Wave Height and Prediction of Wave Occurrence. There is relatively large gap of wave height data for most of the offshore regions in the study area, although broad extrapolations may be made from the few existing observation points such as light ships and short-term platforms. There is a need for many more long-term data on waves for areas such as Eastern Georges Bank. Wave data relating to effects of scour or motion on pipelines may also require specific site location observations over suitable periods. The gaps in this area are somewhat overlapping with associated meteorological data discussed later.

INSHORE

- (1) Estuarine circulation. We need to examine the process of inshore-river mouth circulation, especially in regard to tidal flows that reinforce or alter the residual currents. Certain wide-mouthed, open estuaries such as Casco Bay and Penobscot Bay already measured in some detail exhibit a variation in comparison with narrow estuaries like the Merrimack or the Sheepscot Rivers. The possible introduction of spilled products into one system may differ from another posing a potential hazard in estuaries that behave so as to readily pass subsurface currents into the estuaries.

- (2) Flushing rates. Directly related to the currents that flow into an estuary is the need to describe the flushing rate and how completely are the waters exchanged of any or all the major estuaries. As mentioned earlier, few of these data are available.

27.4 CHEMICAL OCEANOGRAPHY: CHAPTERS 3.3 and 4.3

DATA GAPS AND DEFICIENCIES

There has been a substantial amount of chemical oceanographic information and data collected in the study area. However, there are a number of important parameters for which there are only limited data. Most data available were collected in localized areas with a minimum of supporting chemical and/or hydrographic information to help interpret the operation of the whole system.

BIOLOGICALLY ACTIVE NATURAL COMPONENTS

The distribution of dissolved oxygen, including both seasonal and spatial variations, is well known for most of the areas studied. Generally it is at or near 100 percent saturation. Exceptions are low oxygen in deep water or nearshore polluted areas, and high oxygen within plankton blooms. Further studies of the oxygen concentration need not be undertaken except as support data for other chemical or biological work. Other gases such as nitrogen have been studied very little. Knowledge of nitrogen concentrations is useful in the study of gas exchange at the atmosphere-ocean interface and of physical changes, such as heating, cooling, and mixing of water masses.

Nutrient concentrations have been measured in most areas within the study region. Most data, however, were collected over a short time span and in localized areas. Only a few annual studies have been completed. If more data are needed, they should be collected as part of a larger systematic program in which hydrographic and biological parameters are also measured. Collection of more nutrient data is of little utility unless aimed toward more understanding of the areas involved, such as the entire Gulf of Maine. There is a need for collecting nutrient data in polluted areas, such as Massachusetts Bay, in order to monitor the excess nutrient input. However, unless this work is coupled with a study of the biological productivity resulting from this nutrient input, the data will be of little use in understanding the effect of man on the natural system. There have been few data collected on either total dissolved organic materials (as organic carbon) or on individual, natural organic compounds, such as urea. In seawater, these compounds are found in very low concentrations and are useful in the study organic matter cycling and biological processes. Consequently, study of specific compounds must be coupled with biological studies.

SUSPENDED MATTER

Suspended matter data are lacking for the areas offshore. As above, most of the studies have been conducted in limited areas and lack a systematic approach, both in the spatial and temporal distribution of sample stations. Where particulate matter data have been collected,

interpretation of the processes which control the suspended matter concentrations has been limited by the lack of supporting data.

Suspended matter data for the coastal area are limited. The problem here is the extreme variability of concentrations observed over the tidal cycle, from day to day, from month to month, and year to year, etc. To amass baseline data under these conditions is fruitless. What questions need to be answered concerning suspended matter have been phrased by Meade (1972, p. 259) in a very succinct manner: "Where does suspended matter come from? How far does it travel during a specific event or period of time? Where is it deposited? Once deposited, how long does it stay put?"

Studies of suspended matter conducted to aid in planning or assessing impacts should be conducted on two levels: (1) A regional, systematic baseline study for the offshore waters. Suspended matter data, such as concentrations, light scattering relationships, organic-inorganic ratios, should be collected with supporting physical, chemical and biological data. (2) Process-oriented studies for the coastal areas are needed to define (a) the sources and the sinks of suspended matter; and (b) the relationships between sediment and the controlling energy conditions primarily related to weather conditions.

TRACE METALS AND ORGANIC POLLUTANTS

Pesticides and polychlorobiphenyls (PCB) are entirely manufactured by man. Baseline data on these compounds would show the present levels due to man's activities. There are essentially few data on these compounds; only the nearshore areas have been sampled.

It would be useful to examine the concentrations of these compounds because of the high population density in the northeast United States, and the large important fishery industry in the region. In addition, these baseline data are necessary to help understand the process of dispersal of these compounds once introduced into the Gulf of Maine region.

Trace metals and some hydrocarbons have natural level concentrations which are enhanced in some areas due to man's activities. It is probably no longer possible to obtain natural level data for many of the trace metals along the coasts. Although it is known that most trace metals injected into the coastal areas end up in sediments of that area, the forms of the metals and processes of transportation and dispersion are still not well understood. Consequently, measurement of both the forms of the metals and temporal and spatial distributions must be studied in conjunction with water mass movement and biological parameters. This approach is necessary if processes of trace metal dispersion are to be understood.

Finally, the concentrations, sources, and composition of natural-level hydrocarbons must be determined for this region, particularly on Georges Bank and in near-shore areas that are possible pipeline or tanker terminals. These levels should be determined prior to the onset of drilling for oil on Georges Bank.

Georges Bank is a major fishing area and fish-nursery ground. The physical and chemical oceanographic processes that cause Georges Bank to be such a productive area are not well understood and must be studied. It will be necessary to measure not only the chemical oceanographic parameters such as dissolved oxygen, nutrients, suspended matter, trace metals and organic pollutants, but to relate these parameters to both physical and biological processes occurring at the same time.

A major, multidisciplinary, and probably multi-institutional program will be necessary to collect, evaluate and model the chemical data required to understand the Georges Bank area before the assessment of man's impact can be estimated.

27.5 METEOROLOGY: CHAPTERS 3.4 and 4.4

The largest gap in the coverage of meteorological data is clearly in the offshore areas. With only a very few on station ships and no platforms or buoys, the lack of seasonal and continuous observations is severe. The need is for more observation, if the goal is to be better short-time predictions. These data are needed for engineering operations, exploratory work, as well as for better understanding of wind-driven surface currents on short-term in event of spilled product.

To predict storm tracks we need more hour by hour observations to improve forecasts. One suggestion has been to fully instrument all exploratory and permanent drill rigs for more observations.

The area needing the greatest number of observations is generally north of Cape Cod and in the Gulf of Maine where, as we have seen in trying to estimate currents from ships' logs, the number of ships is decreased to the point that calculations are not meaningful.

27.6 PHYTOPLANKTON: CHAPTER 8

Future phytoplankton studies should include the following five topics:

- (1) Preparation of a taxonomic key to the phytoplankton of the region
At the present time, Marine Plankton Diatoms of the West Coast of North America Coast by Cupp (1950) is one of the most commonly used guides to the local diatoms. There are many instances where this guide is incomplete, e.g., the omission of Porosira glacialis and Detonula confervacea as well as stylized line drawings and size ranges for organisms which do not suit the local forms. The

preparation of a taxonomic reference which includes phytomicrographs of vegetative and resting cells of the Gulf of Maine is long overdue.

- (2) Analysis of phytoplankton dynamics in selected coastal waters. Phytoplankton populations have been studied in detail in only a few locations within the Gulf of Maine. More detailed seasonal data are required on the inshore waters, specifically the waters from Boston, Mass. to Cape Elizabeth, Maine, and along the coastal waters to the South of Nova Scotia. It is at these two locations that the initiation of the spring bloom within the Gulf of Maine is thought to occur and ultimately spreads to other regions. Factors responsible for the step by step initiation and subsequent development of the spring bloom should be carefully identified. After this study is completed, it should be possible to accurately designate species as indicator organisms of specific water masses. Previous information which had described Chaetoceros socialis and Guinardia flaccida as Georges Bank forms has been subsequently shown to be incorrect and based on inadequate sampling of coastal waters.
- (3) Examination of the role of resting spores and cysts in initiating populations of phytoplankton. We have frequently encountered large numbers of resting spores and cysts at the conclusion of the growing periods for many of the major phytoplankters. Often these are found farther offshore in deeper water than in which the healthy populations were collected. Very seldom are resting spores or cysts found when the blooms of the individual species are initiated. We need to know at what depths the resting spores and cysts maintain themselves when they are not a part of the vegetative population within the euphotic zone. It is also important to know the role of the resting spores and cysts in the initial development of the population within the water column.
- (4) Examination of phytoplankton biomass as a constituent of total particulate matter. Coastal and estuarine environments are often "detrital" systems, regions dominated by particulate organic matter. The contribution of the living phytoplankton to the total particulate organic matter is largest during the spring bloom, yet it composes only a small fraction during the remainder of the year. This fact is important when it is remembered that zooplankton, for the most part, feed on particles in an indiscriminate manner. We need more information on the seasonal variability in the coastal region, in the classification, amount, and origin of particulate matters.
- (5) Examination of the role of surface, mid-water and deep water currents in facilitating the development and spread of spring blooms. The currents within the water column of coastal waters

at distances of 8 km and near-coastal waters, out to 80 km, should be better described. Phytoplankton have a specific pattern of development within the Gulf of Maine. The spring bloom spreads to the North from its initial development around Cape Ann in spite of the fact that the surface waters in this region move to the south. It may be that there is a portion of the water mass moving in a northerly direction and it is this water mass which is causing the spread of spring bloom. The experiments conducted by Ketchum (1947) involving the tracing of water mass movements within the Gulf of Maine should be repeated and elaborated on in different portions of the coastal waters of the Gulf of Maine. This information is essential to understanding the timing and sequence of spring bloom.

27.7 ZOOPLANKTON: CHAPTER 9.0

- (1) Abundance and Distribution. Many more data on zooplankton abundance are available south of Cape Cod than in the Gulf of Maine. Also, quantitative surveys have been done on inshore areas and estuaries much more frequently than on the continental shelf and slope. Much of the information in the Gulf of Maine was collected in the 1920's and 1930's with sampling gear no longer in common use. There is a lack of uniformity throughout the area in sampling methods and protocols. There is often considerable uncertainty whether the results of one survey can realistically be compared with another. There is a general lack of sampling of nighttime zooplankton. In neritic and estuarine movements, nighttime zooplankton may contribute significantly to the total plankton present in the water column.
- (2) Environmental Relationships. Although something is known about the vertical migration of some species, much more information is necessary in order to assess quantitatively the ecological significance of vertical migration.

There is little or no information on the reasons why some species are restricted to neritic environments, other species to oceanic waters, while yet other species are apparently able to exist in both.

Temperature and salinity relationships are well known for a few species but not for most.

The role of dissolved organic matter is not well understood. Inorganic and organically bound minerals excreted from zooplankton serve as a nutrient base for phytoplankton growth, but the dynamics of this system are not well understood. Dissolved organic substances have been implicated in phytoplankton-zooplankton dynamics, but the real importance of their role has not been verified.

The feeding relationships of zooplankton are not well understood, including the relative importance of organic detritus in the nutrition of zooplankton.

Virtually nothing is known concerning the sensitivity of zooplankton species to specific pollutants.

- (3) Population Dynamics. There is very little information on the natality, mortality, or growth rates of most species. Some population models have been developed which compare favorably with nature. Further testing of the models for various geographic areas and under various conditions is necessary before they can be used in a predictive sense. The importance of zooplankton as forage for fish and other predators is known for relatively few species. Ctenophores and other medusae apparently can decimate a local population of zooplankters, yet they themselves are not fed on by other organisms. The importance of this apparent "dead end" of a food web is not known.
- (4) Parasites and Diseases. The role of disease on zooplankton is unknown. Parasites are known to be present on some species, but their importance as mediators of growth or mortality is not known.

Priority for Research

Although a great amount of basic and applied research is needed to supply the many data gaps and deficiencies, the following high priority research needs to appear to be paramount.

Sampling

- (1) Needed are standard sampling gear and protocols so that quantitative surveys can be reliably compared and true population distribution and abundance statistics established.
- (2) Field surveys should be concentrated in areas inadequately sampled in the past and in areas where substantial environmental modifications are anticipated.

Experimental Biology

- (1) Emphasis should be placed on key species which are probably more important to the ecosystem because of their seasonal abundance, ubiquity through the area, or both. Initially, the literature should be exhaustively searched for specific information on various life history components for each of the key species. Time constraints have prevented this search for the purposes of this present environmental survey.

- (2) Following the literature search, new research should be initiated to supply missing life history elements. Particular attention should be paid to providing environmental tolerances for these species including, but not limited to, the sensitivity of the species to selected pollutants.

27.8 BENTHIC INVERTEBRATES: CHAPTER 10

- (1) Abundance and Distribution. Quantitative data are available now for New York Bight (Sandy Hook Laboratory); Long Island Sound; southern coast of Long Island; Block Island Sound; Narragansett Bay; Buzzards Bay; Cape Cod Bay; Barnstable Harbor, Mass.; Boothbay Harbor, Maine; Georges Bank (NMFS Northeast Fisheries Center, Woods Hole).

Qualitative or semi-quantitative data are available for Woods Hole Region, Ipswich Bay, Casco Bay, Mt. Desert Island, and Cobscook Bay.

Data are scattered north of Cape Cod. Quantitative surveys are needed in coastal areas from Boston to Eastport, and in basins of Gulf of Maine. Also, quantitative surveys are needed on fishing banks other than Georges.

- (2) Community Structure and Relationships. Descriptive ecology of communities in coastal areas north of Cape Cod are scarce. Virtually no quantitative information exists on competition between species; dependence of one species on another is also poorly known. Food habits of bottom feeding fish are fairly well known. However, food requirements of the invertebrates themselves are poorly known, especially the quantities consumed and preference, if any, except for a few economically important species.
- (3) Population Dynamics. Except for a few economically important species, or occasional organisms commonly used in experimental biology, little information is available on natality rates, natural mortality, growth rates or life span.
- (4) Environmental Requirements. Temperature tolerances and preferences, oxygen requirements, effects of siltation, sensitivity to pollutants, salinity tolerances, and similar data are only partly known for important species and virtually unknown for most others.
- (5) Behavior. Reactions to light, currents temperature gradients, and chemical cues only partly known for a few species; they are virtually unknown for most.

- (6) Reproduction. Spawning seasons and larval development are fairly well known for many species, especially those also found in European waters, since much of the study of these phenomena has been done in Europe.
- (7) Parasites and Diseases. Parasites are fairly well studied; practically nothing is known of diseases except for oysters.
- (8) Productivity. A few estimates of bottom productivity have been made, but more are needed, especially in the coastal areas of the Gulf of Maine.

Priorities of research needed.

- (1) Field surveys. Complete quantitative benthic fauna surveys should be made in selected localities in coastal waters between Cape Cod and Eastport. These should include densities of all benthic species, biomass determinations by species, indices of species diversity, association coefficients, sediment analysis, hydrographic measurements, stomach analyses, size distributions, egg counts of gravid individuals, and age determination where possible. Ideally, the surveys should be made twice a year, and should include several bottom types. At least two estuarine localities should be studied with transects from fully marine conditions to oligohaline estuarine conditions. Suggested localities are: Cobscook Bay, Narraguagus estuary, Penobscot Bay, Casco Bay in Maine; Ipswich Bay and Duxbury Bay in Massachusetts.
- (2) Experimental biology. Available published and unpublished information for all of the key species, especially that dealing with environmental requirements should be re-examined thoroughly. Time restrictions have limited the amount of data included in the Key Species Life History data sheets. Much information still needs to be extracted from the literature as well as from foreign publications, obscure and hard-to-find journals, "in-house" publications of various institutions; other sources would undoubtedly contain much additional data. The life history data sheets should be made as complete as possible.

New research should emphasize two major aspects of invertebrate biology: environmental requirements and tolerances, and inter-species dependence. For the first, a protocol should be developed to investigate a few critical factors such as upper lethal temperatures, minimum oxygen requirements, and sensitivity to certain selected categories of pollutants. For the second, feeding, predation and competition should be investigated quantitatively. Obviously, these investigations cannot be made on all species, but they should be done for many of the key species. A few of the key species for which considerable additional information is

required are:

Arctica islandica

Pectinaria gouldii

Nephtys incisa

Polynices duplicata

Nucula proxima

Tellina agilis

Mytilus edulis

Clymenella torquata

Corophium volutator

Spisula solidissima

Macoma balthica

There are, of course, several others that could be included. The above species represent the following categories:

Important commercial species which have not had the attention their importance deserves.

Species, which thought very common, have not been intensively studied.

Important forage organisms.

Species of potential value as indicator organisms.

27.9 FISHES: CHAPTER 12

We would estimate that 75 to 80 percent of the literature pertinent to fishes of the Gulf of Maine and 45 to 50 percent of the literature pertinent to fishes of the mid-Atlantic Bight from Cape Cod to New Jersey were reviewed for the fish chapter.

State of Knowledge

It is difficult to summarize the present state of knowledge of the fishes in the study area without a species-by-species description. The fishes are such a diverse group that most research has been on single species and these have generally been the economically important ones. Therefore, there exists a wide variation in the amount of information available, a considerable amount of life history data accumulated for a few commercially important species, and very little information on a large number of ecologically important ones.

Most research has been oriented toward problems associated with commercial or sport fishing. There has been very little work done on problems associated with man's contamination of the environment. Probably the two most important gaps in our knowledge that apply to contaminants

are:

- (1) Life history data of species needed for baseline information in assessing impacts, and
- (2) What the effects of contamination are on the life history stages of the important or key fish species.

The following is a brief comment on general gaps in knowledge for each of the major subjects in the fish chapter.

Zoogeography. In order to determine the impact of offshore development activity on the fishes of any particular locality, it is necessary to know to what degree these localities are important to the life history of each species. This requires rather precise analysis of the seasonal and areal distribution of at least the more important fishes in the study area. This information does not at present exist in a usable form for most of the fish species. There are three categories in which information is lacking:

- (1) Distribution data that exists but are scattered throughout the published and unpublished literature. This material needs to be compiled, synthesized, and made available. These data are mostly from offshore ground-fish surveys, small-scale inshore surveys of different types, or studies of individual species.
- (2) Distribution data that do not exist and require future research. These apply particularly to the pelagic species which are more difficult to sample and the small nearshore and intertidal fishes that are of no particular commercial value.
- (3) Temperature preferenda for the most important species. This information is either scattered throughout the literature or not available at all.

Reproduction. The most sensitive part of the fishes life cycle is reproduction. It is probably the most important to understand in terms of the impact of the effects of oil or other toxic material. What is known of the spawning, egg, larval, and juvenile stages of fish varies greatly from species to species, depending to a large extent on its economic importance. For the major species, the spawning areas and times are at least broadly known, the egg and larval stages described and their general distribution, and times of abundance known. The distribution of juveniles is probably less well documented. The data gaps that have particular significance for oil impact are:

- (1) The vertical distribution of fish eggs and larvae

and their vulnerability to oil contamination.

- (2) The degree to which juvenile fishes are vulnerable to oil contamination in the nearshore area.

Food and Feeding. The food of most fishes in the study area is known only in a general way and is available in Bigelow and Schroeder (1953) and Nichols and Breder (1927). There are also a number of detailed food studies for a few species, primarily groundfish such as haddock. What is not yet well understood is the predator-prey and predator-predator relationships within a particular community; the degree of competition and the division of food resources among various community components of fishes; and the major pathways of energy flow through the prey community to the fish community. These relationships are particularly important in considering oil impacts because of the possible movement and accumulation of contaminants in the food chain.

Life History Information. The key species descriptions in the fish chapter are not complete. Such areas as physiological responses were not well covered and even for the more important species there are gaps of information due either to unavailable literature or no information at all.

It is safe to say that we do not know enough about any of the fishes to be able to assess the effect of oil and offshore activities on them.

The fishes that were treated as key species in the chapter were only a selection of important species and there are many more that should be considered for life history profiles, because they are major components of their particular habitats. A few of the species for which there is a lack of life history information are listed below:

- Little skate
- Winter skate
- Tomcod
- Fourbeard rockling
- Alligator fish
- Threespined stickleback
- Northern pipefish
- Sea snail
- Windowpane flounder
- Smooth flounder
- Longhorn sculpin
- Shorthorn sculpin
- Sea raven
- Rock gunnel
- Snake blenny
- Radiated shanny

Wrymouth
Wolffish
Ocean pout
Goosefish

Research Priorities

The following are general directions in which research could proceed to provide needed baseline information prior to OCS:

- (1) To continue compiling life history data on a species by species basis. This includes the addition of new information to the existing key species given in Chapter 12 and the addition of new key species to the profiles. The work would include a more intensive literature review and new research in areas where no data existed. Special emphasis for new research would be on new species for which data are lacking. Included would be seasonal and areal distribution temperature preferenda.
- (2) To begin field investigations of fishes as part of the biological community of a particular habitat, particularly habitats that are vulnerable to oil spills (i.e., worm and clam flats, salt marshes) to determine the relationships between fish species and between fishes and other organisms of the community food, competition, predation, and major energy pathways that should be studied.

27.10 MARINE BIRDS: CHAPTER 13.0

The thrust of these recommendations is directed at needs for avian research in areas directly or indirectly associated with future coastal and offshore developments that might interact with birds. These comments are drawn from experience both with the TRIGOM-BLM inventory of the northern Atlantic seaboard, and the American Petroleum Institute commissioned inventory of the mid-Atlantic Bight.

If one states that a development is going to have an "impact" on a bird species, one usually means that the development will have some influence on population numbers, and/or the distribution of the species. Since many bird species have natural fluctuations in their population numbers, we need to:

- (1) Acquire baseline population data of important species. As a result of the various inventories, we have some idea of the "important" or "key" species of the area. In many cases, very basic information on the life cycles of the animals is either non-existent, or questionable. If it is necessary to judge whether some outside force will have an effect on a population, it is necessary to know the population ecology of the species. Detailed

studies of fecundity, breeding success, and other elemental population parameters need to be gathered on the important species of the area.

Prediction should be the aim of the planner. Since birds live a cyclic existence, it is necessary to know the history of a population to predict future trends. There are some long-term studies, such as the Audubon Count, but they can be attacked on a number of grounds. Therefore, we should:

- (2) Expand the Audubon Christmas Count, and the Migratory Bird Population Station Breeding Bird Census. These counts should be a source of neutral data from which proponents and opponents of development can draw their conclusion. A funding level consonant with the need, and a scientific board of directors (a small group preferably) drawn from industry, conservation, university and government personnel, as well as having more personnel available to count, and state-of-the-art data processing equipment.

Birds play an extremely important role in the coastal and off-shore ecosystem. The seabirds have a massive influence on the fertile top surface of the sea by dropping guano. Large quantities of energy are therefore transferred from the terrestrial to the marine environment, and vice versa, as birds take food from one area, and drop feces in another. The number of good studies on energy and mineral transfer by birds is tiny. Since, in the worst case analysis, we must consider the possibility of a massive bird kill due to some development associated effect, we must know the ramifications of such an event. Would fish productivity be affected by a kill of neritic fishing birds? How important are birds in the total energy picture of the vital estuaries? Questions like these might be answered by:

- (3) Studies on energy and mineral flow through birds in important areas. The studies might best be funnelled through universities, since the topic is, happily, of both basic and applied interest, and could provide adequate student studies. The results of these studies would provide a realistic basis for assessing "impact" of development.
- (4) More studies are needed on the physical and physiological effects of immersion in, and ingestion of petroleum products. There is already some good work in this area, but the complete study has not been done. There is a need for basic study as well as applied studies.

The final recommendation involves consideration not just of the study area, or questions of development, but the whole matter of man-bird relations. Birds are of enormous importance to humans, and not simply for aesthetic reasons. Birds have a vital economic

role in aviation, agriculture, recreation, and many other areas. There is a great need to coordinate the many bits and pieces of avian research that are oriented toward practical ends. Dozens of federal and state agencies have something to do with birds, and birds are extremely popular organisms for many areas of basic scientific research. There is little coordination between various programs. Since birds are so important in any assessment of development, we suggest:

- (5) A national Applied Ornithology Center be established whose function would be to provide a clearing house service for those in need of applied ornithology, and those capable of providing same. The center would also act as a data bank, and information retrieval service for applied ornithology problems. Clients of the service might be corporations or industries with a bird problem, contractors preparing inventories or impact statements, conservation groups or government. Since there is so much interest in development of the coastal northeast, a center might be started here on a modest basis, and if successful, expanded to a broader national coverage.

27.11 MARINE MAMMALS: CHAPTER 14

The following studies and research programs are recommended to provide reliable research data on all stocks of marine mammals which inhabit Gulf of Maine waters. So little data are available for seals, and particularly cetaceans in New England waters that all research categories deserve immediate funding consideration in a coordinated effort to implement the Marine Mammal Protection Act. Goal of such a program would be:

- (1) Assessment of marine mammal stocks and the acquisition of reliable data of abundance and trends of each species and the testing of new and innovative census methods. Work toward this goal has just begun in the Gulf of Maine as described previously in Chapter 14.
- (2) Delineation of all geographic populations for each species including knowledge of migrations. Little is known of the breeding grounds and migrations of gray seals and cetacean species using Gulf of Maine waters.
- (3) Investigation of ecosystem relations of marine mammals and their environment including: food and feeding methods; whelping habitat and description of "nursery areas" for each species; priorities for habitat preservation so that cetacean and pinniped species may escape harassment.

Whelping habitat utilized by harbor seals in the Mount Desert and

Boothbay areas of Maine is fairly well known, but little is known of other coastal areas for this species.

- (4) Knowledge of population parameters for each species including fecundity, rates of recruitment, and mortality and effects of population density on these factors. Reliable data exist for west coast and Canadian harbor seal populations and eastern Atlantic gray seals; less is known for the western Atlantic gray seals. Study of the important remnant gray seal colony at Nantucket is sorely needed to maximize chances for successful breeding of this species in U. S. waters.
- (5) Investigation of biochemical, physiological, and possible behavioral effects of oil spills, organochlorides, heavy metals and other contaminants are greatly needed. Considerable data are given in the key species descriptions of reported levels of contaminants found in wild seal populations but little is known of possible impact such contaminants may have upon long-term survival of each species.

Incidence of natural diseases and parasites as well as possible man-induced illness in seals and cetaceans as a result to habitat deterioration is not known.

The presence of seawater emulsions of oil would seem to be noxious and irritating to seals and whales, if not toxic. However, the scant reporting of effects of oil spills on marine mammals on the West Coast would suggest that the mobility of these animals removes them from immediate areas of contamination. It seems more likely that food chain concentrations of toxic components of contaminants found by monitoring levels in seal tissues will continue to serve as evidence of trends in habitat pollution. Work in the Gulf of Maine sampling harbor seal and harbor porpoise populations for tissue burdens of metal and organochlorine residues is being conducted by Canadian workers (Gaskin, *et al.*, 1973, 1973b, 1972, 1971).

- (6) Preservation of wild habitat is perhaps the most critically important activity to ensure the long-term survival of pinniped and cetacean species. The Marine Mammal Protection Act of 1972 provides a refreshing and thought-provoking perception of man's relationship with wild creatures and their habitat.

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